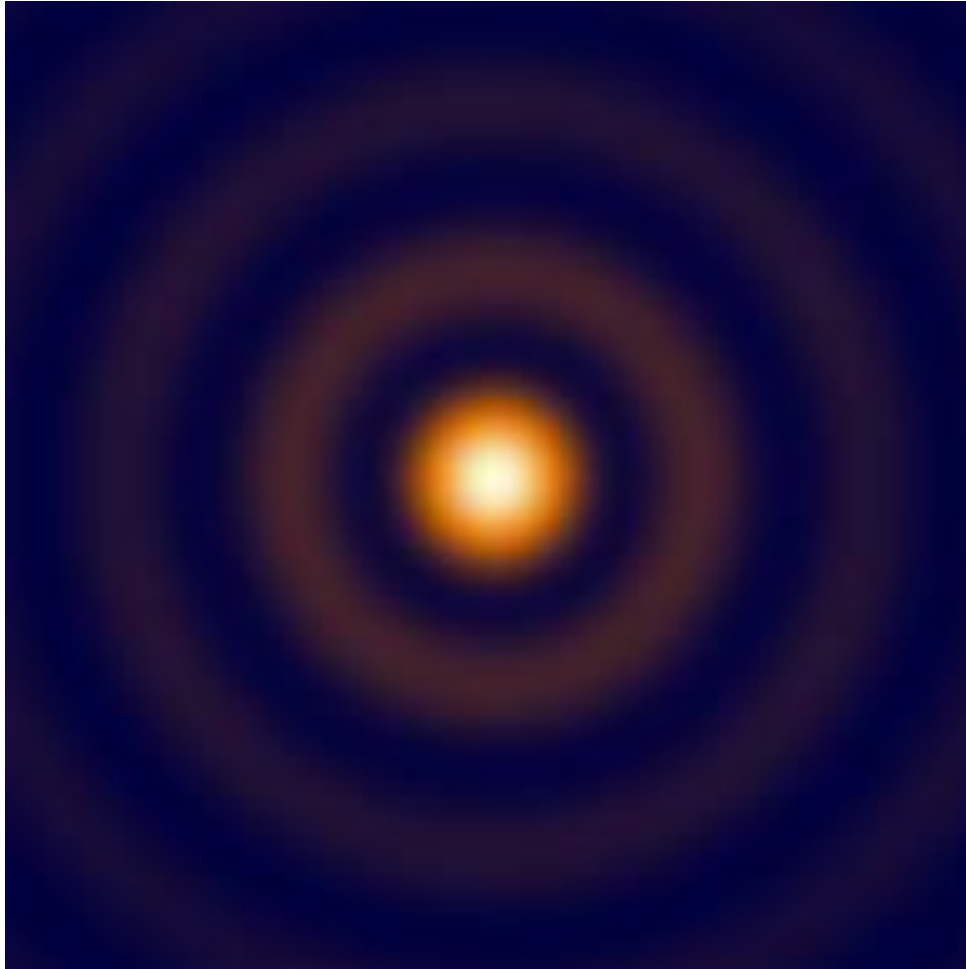


# **Tight Focusing of Various Polarized Beams by an Idealized Aplanatic Lens**

# Abstract

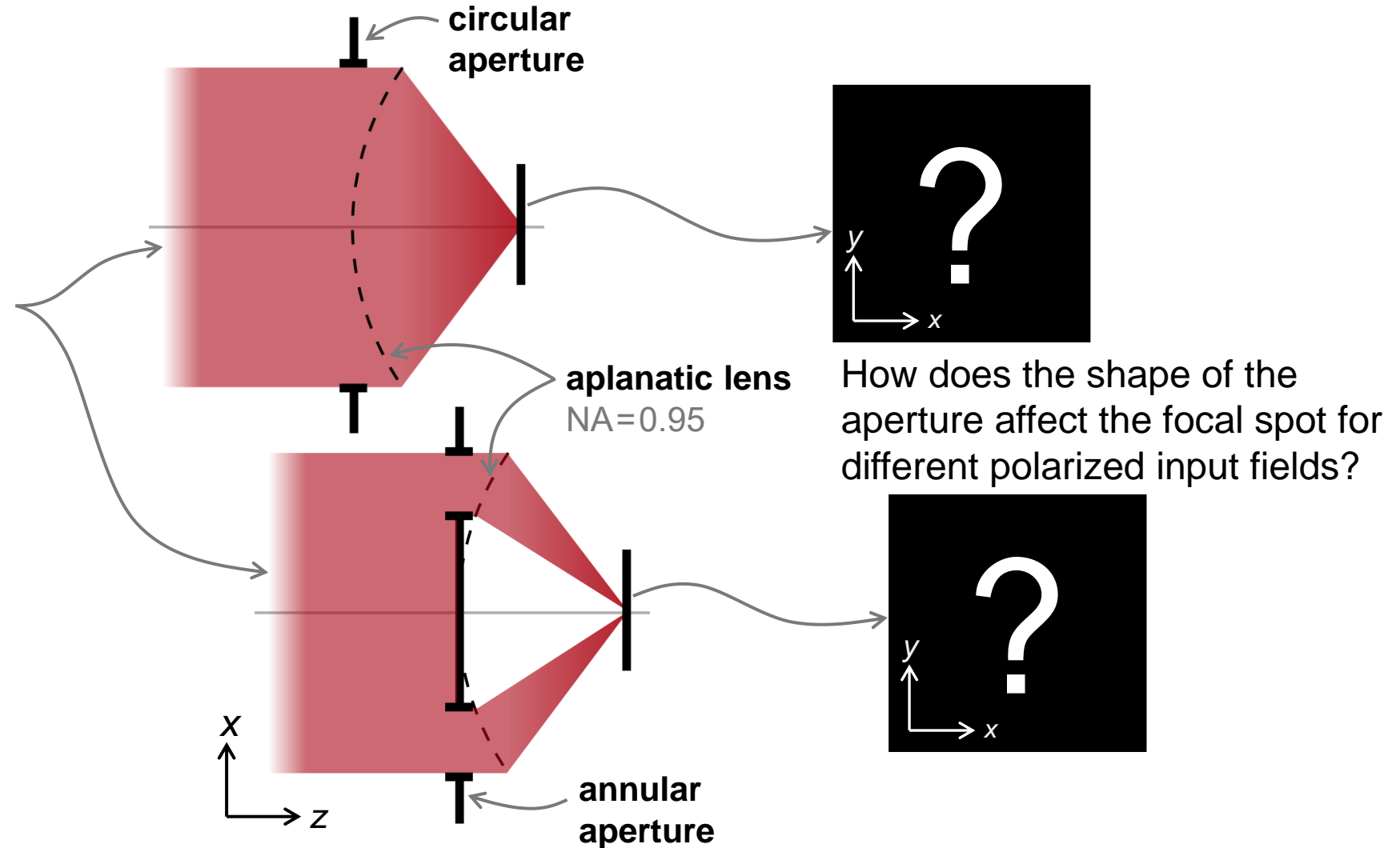


Knowing the vectorial electric field distribution near the focus of a high-NA objective lens is of great importance for applications e.g. microscopy, optical tweezer, laser machining, etc. The used high-NA objective lens is often assumed as an aplanatic lens (means spherical aberration and coma are neglected). We demonstrate the focusing of variously polarized beams, e.g. linearly, circularly and radially polarized beams, by an idealized aplanatic lens in VirtualLab Fusion. Further, the focal field with respect to different shapes of apertures, e.g. circular and annular, is investigated.

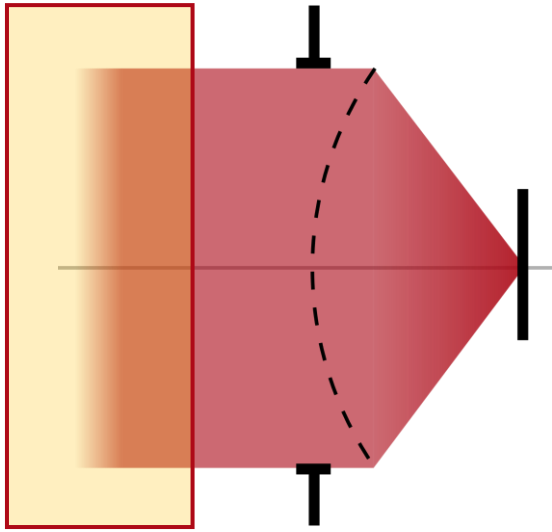
# Modeling Task

## input field

- wavelength: 632.8nm
- Gaussian profile
- polarization states
  - 1) linearly polarized
  - 2) circularly polarized
  - 3) radially polarized

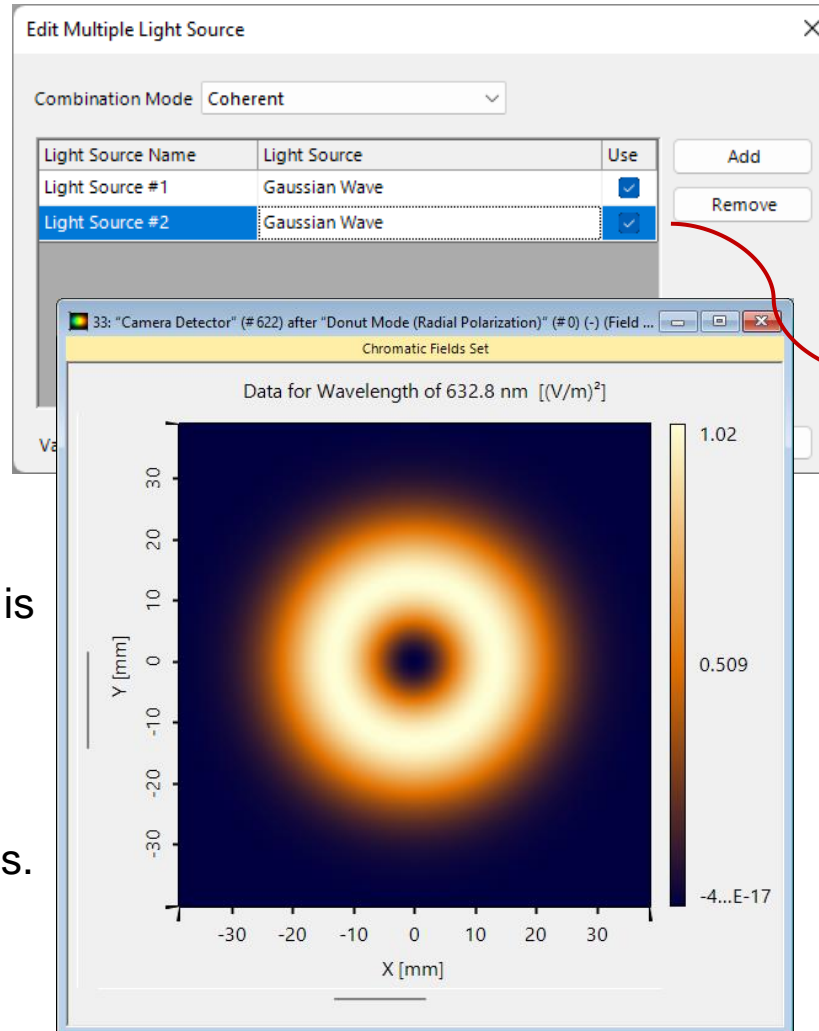


# Multiple Light Source – Radially Polarized Light



In order to model radially polarized light, it is required to combine two different source modes. This can be done by using the *Multiple Light Source*, which enables the combination of e.g. two Gaussian waves with different modes and polarization states. More information under:

[Simulation of Multiple light Source with VirtualLab Fusion](#)



**Edit Gaussian Wave (Linear Polarization)**

Basic Parameters | Spectral Parameters | Spatial Parameters

Polarization | Mode Selection | Sampling | Ray Selection

Global Polarization  Local Polarization

Polarization Input

Type of Polarization: Linearly Polarized (selected)

Angle:

**Edit Gaussian Wave**

Polarization | Mode Selection | Sampling | Ray Selection

Basic Parameters | Spectral Parameters | Spatial Parameters

Generate Cross Section

Hermite Gaussian Mode (selected)

Order: 1 0

M<sup>2</sup> Parameter: 3 1

Reference Wavelength (Vacuum): 632.8 nm

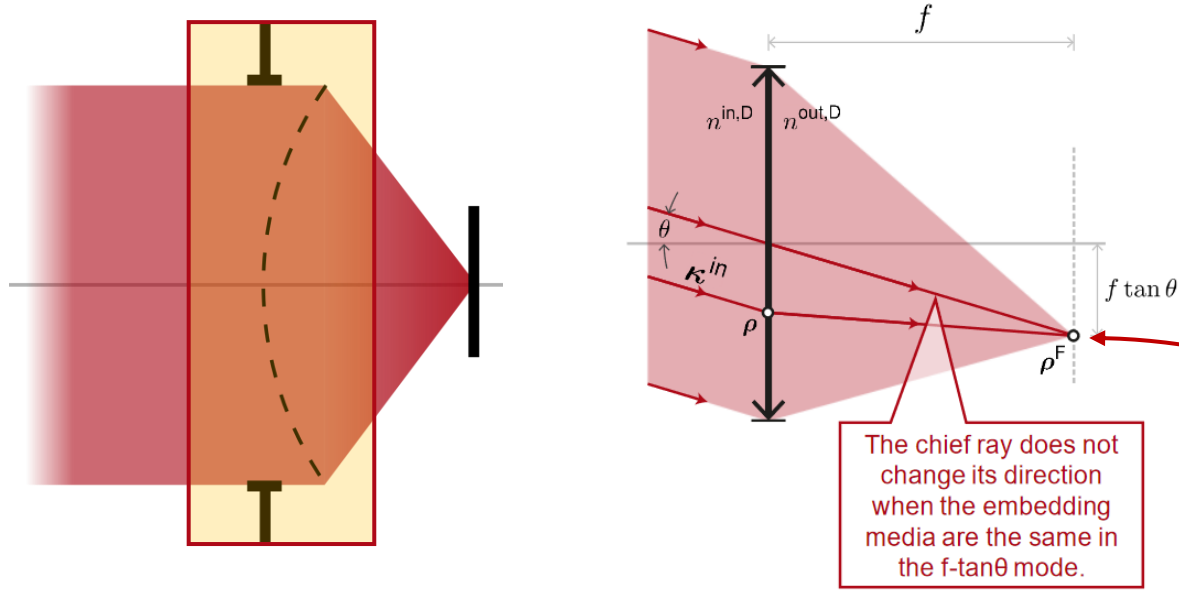
Select Achromatic Parameter:

Waist Radius (1/e<sup>2</sup>) 32.56176883 mm x 18.799546 mm

Half-Angle Divergence (1/e<sup>2</sup>) 0.001063291877° 0.0006138918515°

Rayleigh Length 1.7546 km 1.7546 km

# Idealized Aplanatic Lens



Edit Idealized Lens [Focusing Mode] Component

Bounding Box    Component Specification

Input Field Preparation (for Classic Field Tracing)

Relative Position of Field to Position of Input Transface ⓘ

Keep Stored in the Field's Coordinate System

Resolve via Zero Padding

Algorithms

Input Transface	<input type="button" value="Edit"/>	Validity: <input checked="" type="checkbox"/>
Snippet for Equidistant Field Data	<input type="button" value="Edit"/>	Validity: <input checked="" type="checkbox"/>
Snippet for Non-Equidistant Field and Ray Data	<input type="button" value="Edit"/>	Validity: <input checked="" type="checkbox"/>

Parameters

DesignWavelength	<input type="text" value="632.8 nm"/>
DesignNin	<input type="text" value="1"/>
DesignNout	<input type="text" value="1"/>
FocalLength	<input type="text" value="6.5 mm"/>
LensType	<input type="text" value="0"/>
OutputMaterial: "Air"	<input type="button" value="Load"/> <input type="button" value="Edit"/> <input type="button" value="View"/>

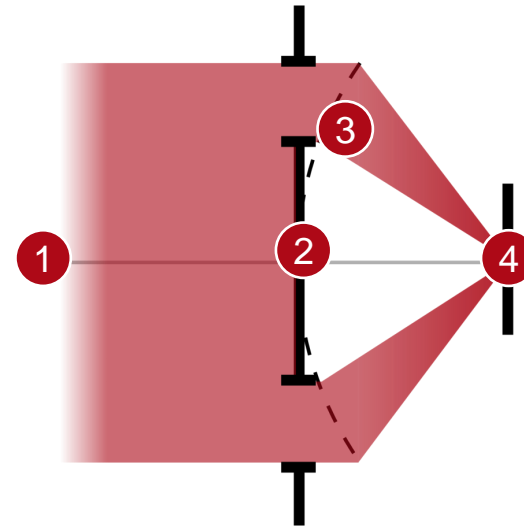
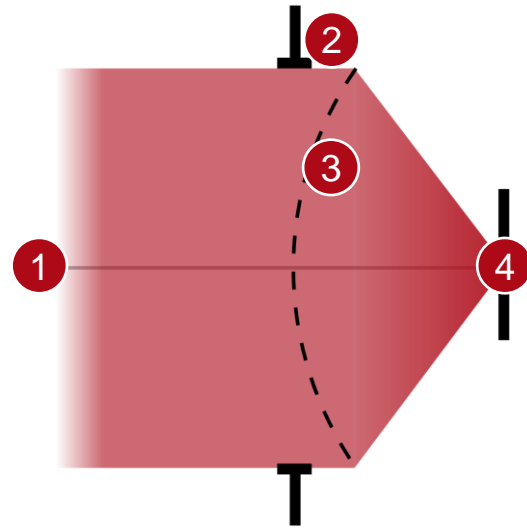
Virtuallab provides different types and definitions of idealized lens functions. In this Use Case we utilize an ideal focusing lens which provides an f-tantheta functionality. More information under:

[Idealized Lens Functions](#)

$$f\text{-tan } \theta \text{ mode: } \rho^F = f \tan \theta \frac{\kappa_z^{\text{in}}}{\|\kappa^{\text{in}}\|} = f \frac{\kappa_z^{\text{in}}}{k_z^{\text{in},D}},$$

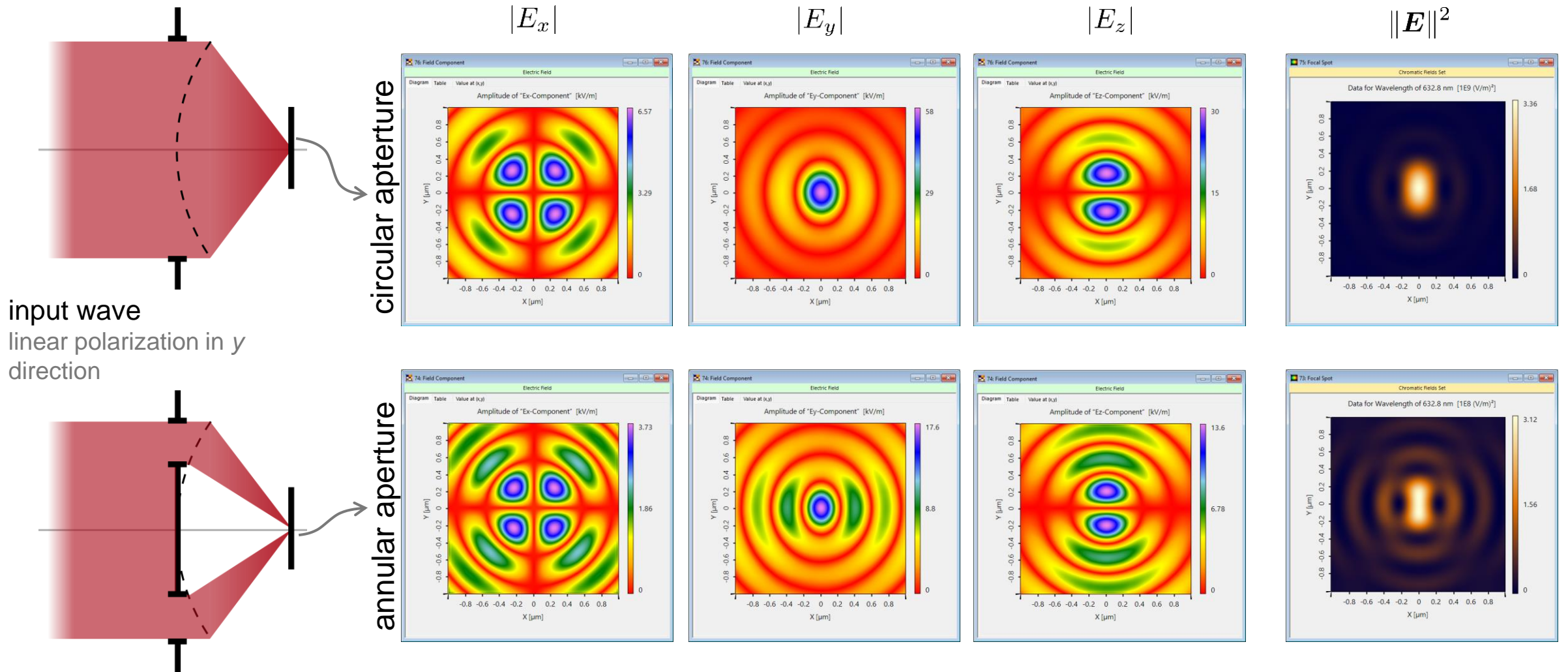
$$\text{with } k_z^{\text{in},D} = \sqrt{(k_0^D n^{\text{in},D})^2 - \|\kappa^{\text{in}}\|^2};$$

# Summary – Components...

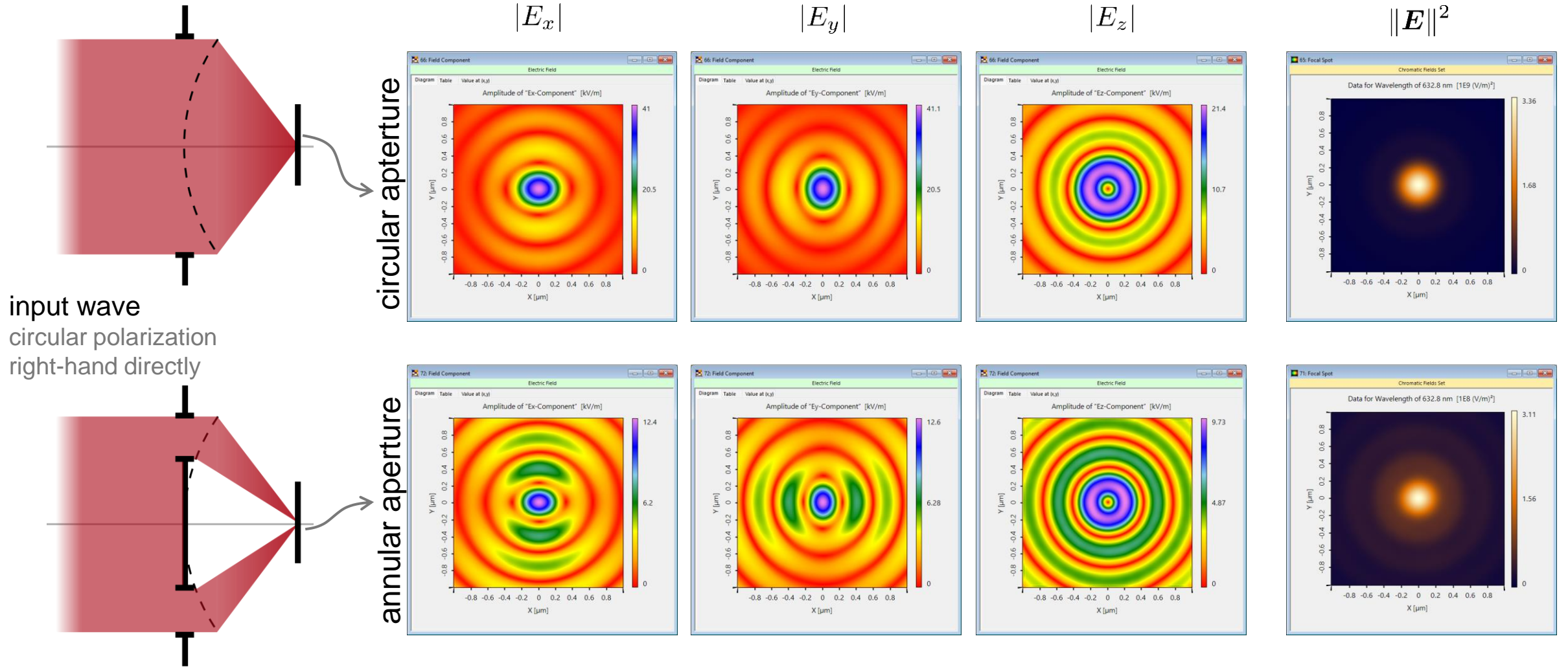


... of Optical System	... in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. source	<i>Gaussian Wave / Multiple Source with Gaussian Waves</i>	Hermite Gaussian modes
2. aperture	<i>Aperture / Stop</i>	transmission function
3. idealized aplanatic lens	<i>Idealized Lens (Focusing Mode)</i>	transmission function
4. detector	<ul style="list-style-type: none"> <li><i>Camera Detector</i></li> <li><i>Electromagnetic Field Detector</i></li> </ul>	<ul style="list-style-type: none"> <li>energy density measurement</li> <li>field component measurement</li> </ul>

# Circular vs. Annular Aperture: Linearly Polarized Input

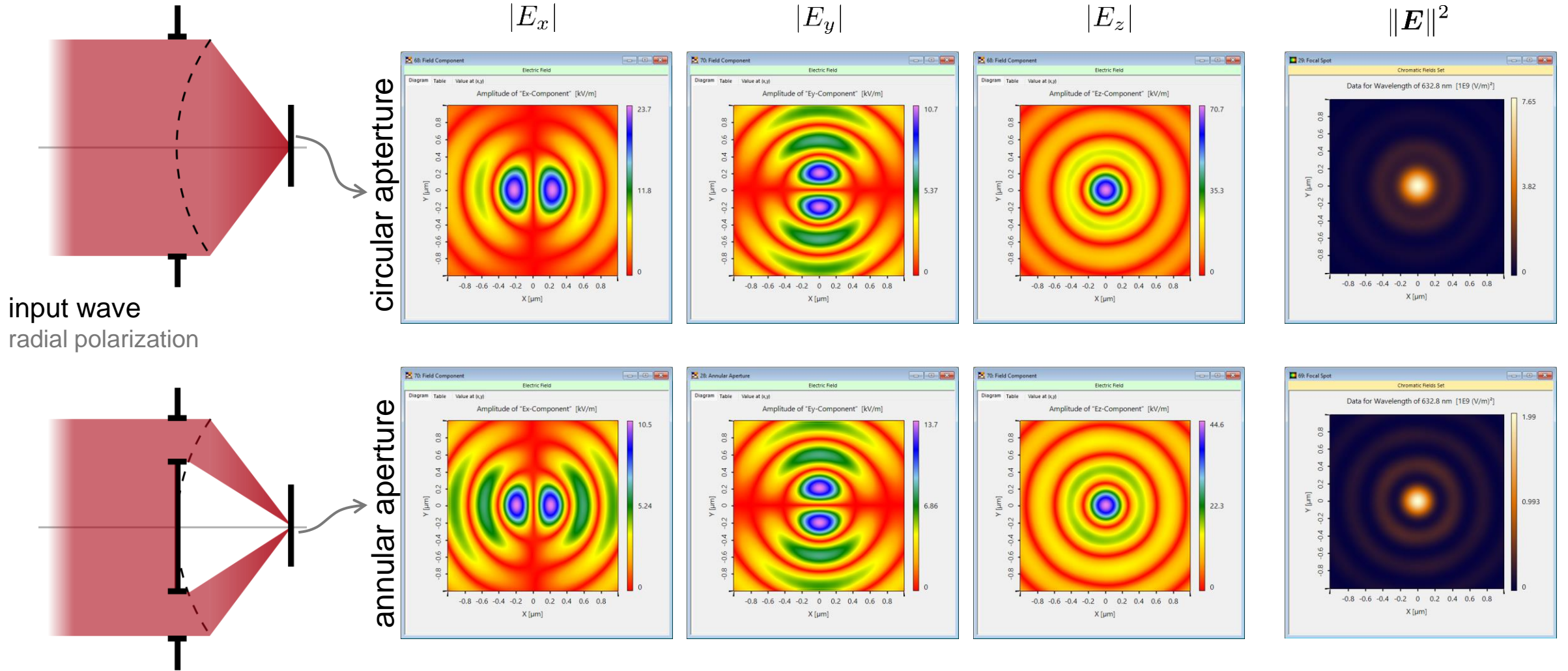


# Circular vs. Annular Aperture: Circularly Polarized Input

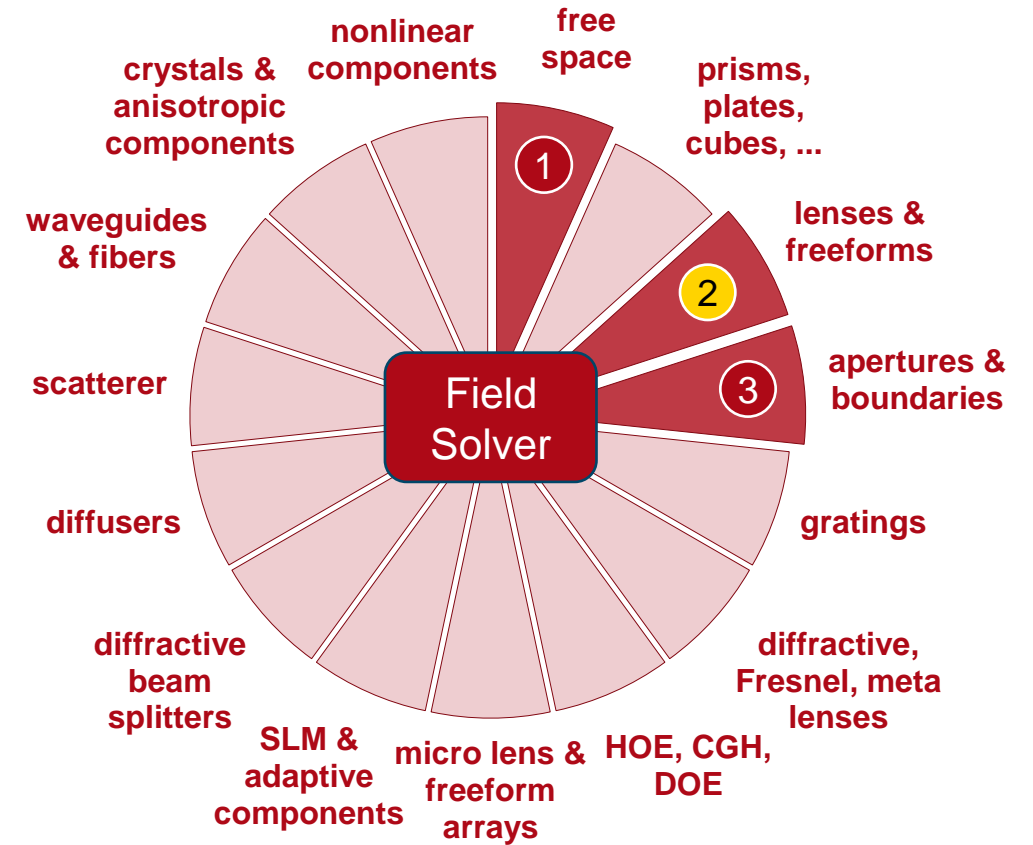
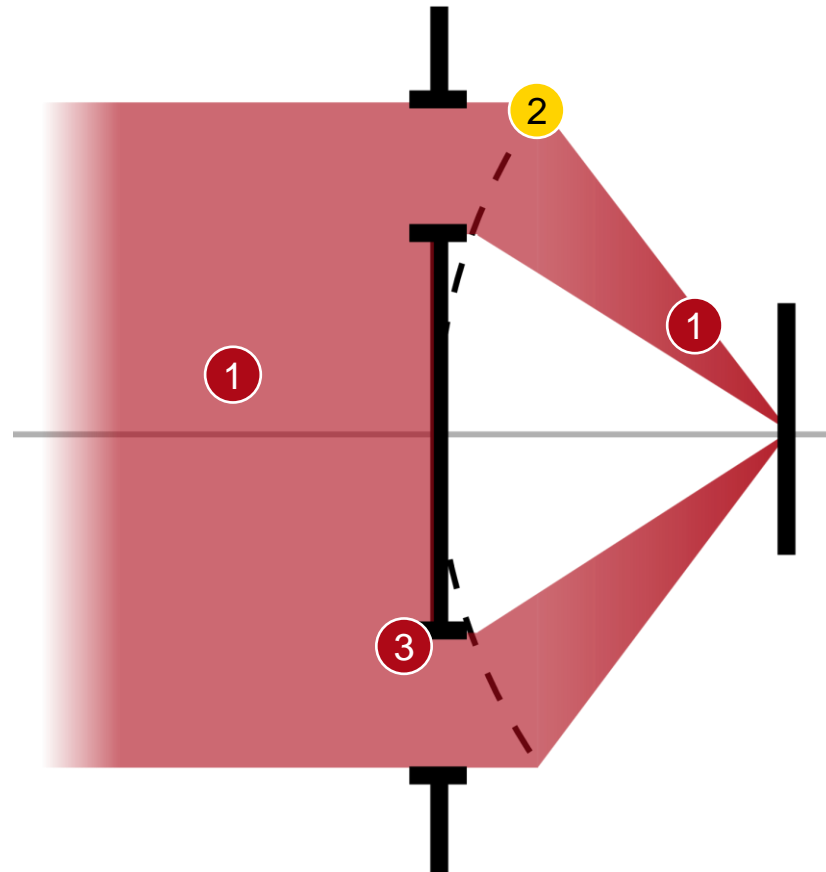




# Circular vs. Annular Aperture: Radially Polarized Input



# VirtualLab Fusion Technologies



# idealized component

# Document Information

title	Tight Focusing of Variously Polarized Beams by an Idealized Aplanatic Lens
document code	MIC.0005
document version	1.1
software edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none"><li>• <a href="#"><u>Analyzing High-NA Objective Lens Focusing</u></a></li><li>• <a href="#"><u>Investigation of Idealized Vectorial Focusing Situation Using Debye-Wolf Integral</u></a></li><li>• <a href="#"><u>Simulation of Multiple light Source with VirtualLab Fusion</u></a></li><li>• <a href="#"><u>Idealized Lens Functions</u></a></li></ul>